UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN No. 119

February, 1906.

Abstract of Eighteenth Annual Report,
1904-1905

[Potato diseases and their remedies]
L. R. Jones & W. J. Morse

BURLINGTON:
FREE PRESS ASSOCIATION
1906.

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Director's office, chemical, horticultural and veterinary laboratories are at the Experiment Station building, at the head of Main street; botanical laboratories are at Williams Science Hall, University place.

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BULLETIN 119: ABSTRACT OF EIGHTEENTH ANNUAL REPORT, 1904-05

JOSEPH L. HILLS

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INTRODUCTION

Following the precedent established two years ago a 48-page abstract of the 225-page report is presented herewith in which the matters of more directly practical interest are briefed. Such of the recipients of this bulletin as desire to receive the full report have but to ask to receive, specifying it by its number—eighteen.

The matter touching potato diseases is condensed from the reports of the botanists, Professors Jones and Morse; that which concerns lettuce growing, soil sterilization, fruit trees and insects is taken from the matter furnished by the horticulturist, Professor Stuart; that concerning maple products is but a fragment of a technical article having to do with adulteration and its detection, furnished by the Station chemist, Mr. C. H. Jones; while that having to do with dairy matters is the product of the writer.

THE OCCURRENCE OF PLANT DISEASES IN VERMONT IN 1905

ORCHARD CROPS

The apple and pear diseases of chief importance in this region are scab and blight. Neither has done serious harm since the spring drought of 1903, which evidently almost exterminated these parasites from Vermont orchards. Except for this fact there could hardly have failed to be considerable scab the past season. As it was there was only a moderate development of this fungus and small loss, despite the fact that less than the usual amount of orchard spraying was done. There was more scab than in 1904, however, and in the writer's judgment there is a sufficient reestablishment of the fungus in most Vermont orchards to augur serious damage from it another year, providing weather conditions favor. The renewal of spraying operations where they have been held in abeyance the past two seasons is therefore to be urged. The same general statements will apply as to the occurrence of the blight. Less than usual has been observed since the drought but enough was seen this summer to start the epidemic next year if climatic conditions favor.

The injuries resulting from the winter killing of 1903-04 were still in evidence this summer, many of the trees which recovered showing but weakly growth. In one such case, examined in August, 1905, it was found that most of the wood of the preceding year was brown and dead, although the cambium had survived.

The cherry and plum crops were heavier than common in 1905. The brown rot (*Monilia*) made its appearance unusually early, attacking the fruit spurs of the sweet cherry in some cases before the flowers were fully faded. It continued to develop persistently on the sweet cherries and, later, on the more susceptible varieties of plums, destroying not only the young fruits but killing the fruiting twigs back to the main branches. Probably the average loss amounted to from 10 to 25 percent of the crop. Extra precautions should be taken this winter to clean out such orchards.

GARDEN CROPS

No maladies of peculiar interest were observed on garden crops other than the potato. Some cases of bacterial soft rots of vegetables came to our notice. In one of these, turnips were growing alongside rutabagas. The former rotted badly, while the latter showed none of the trouble, indicating clearly a relatively greater liability of turnips to the disease. The Station horticulturist observed a similar bacterial rot of the tap-root of parsley. This was growing in soil where turnips

rotted badly last year, and is strong evidence that these diseases are perpetuated from crop to crop in garden soils. The increasing number of reports of club-root of cabbage and allied crops indicate that the germs of this disease are being more widely scattered year by year. Where one values his soil for the production of these cruciferous crops he should be cautious about setting purchased cabbage plants unless he knows them to be from soil free of the disease. It is believed that much new infection has occurred in this way during recent years.

POTATO DISEASES

The climatic conditions of the summer of 1905 were in general favorable for the potato crop until September.

Tip-burn.—Tip-burn did only a moderate amount of damage, less than it ordinarily does.

Early blight.—There was less early blight (*Alternaria solani*) than usual, except on light soils. On these it developed destructively throughout August and early September and materially shortened the life of the plants, as will be shown in detail later in this report.

Late blight and rot.—The amount of rot which occurred in 1904 made the recurrence of the late blight in 1905 a certainty, provided climatic conditions favored. Until the latter part of August such conditions were not generally present. This blight was first observed on potato leaves August 13. Thereafter it spread but slowly for some time. Examinations of numerous fields made August 23 showed that the fungus occurred in practically all of them, but it was not as yet conspicuously destructive anywhere, early blight being much more in evidence at that date. During the last week of August, however, it spread persistently, but did not become generally conspicuous until the first week of September. This week was warm with frequent gentle rains and the foliage on all except favorably situated or resistant varieties rapidly blackened and was soon practically ruined. The weather continued sufficiently rainy for two weeks thereafter to afford ideal conditions for the rot and the resultant loss was exceptionally great, many fields on low or heavy soil not being worth the digging. This is in considerable degree unnecessary, as is shown later.

POTATO DISEASES AND THEIR REMEDIES

I. RESULTS FROM SPRAYING EXPERIMENTS

SPRAYING THE VINES FOR LATE BLIGHT AND ROT

The potato field chosen for the spraying experiments against late blight and rot in 1905 was planted the middle of May with Delawares. The soil was a well-drained gravelly loam in good fertility.

Twenty-four rows were staked off for the experimental work, the balance being sprayed in connection with the regular farm operations. These twenty-four rows were divided into four plots of six rows each. Plots 1 and 3 were sprayed alike with bordeaux mixture, plots 2 and 4 being left as controls and treated only with paris green.

The bordeaux mixture used consisted of 6 pounds of copper sulphate, 4 pounds of lime and 40 gallons of water, with the addition of one-half pound of paris green. Two applications of this mixture were made on August 2 and 21, respectively. The first traces of the late blight fungus were seen on the leaves of the control rows August 13. It spread but slowly until about September first. Thereafter, being favored by moist warm weather it worked rapidly over these rows, soon destroying the tops. The sprayed plants held their foliage well through September. The plots were dug and sorted October 13. The outside rows of each plot were rejected to insure greater accuracy. The results as shown by the remaining rows are as follows:

Plot	Treatment	Yield sound	Rotten
I.	Bordeaux mixture,	342	8
II.	No fungicide,	191	46
III.	Bordeaux mixture,	422	4
IV.	No fungicide,	232	66
	Average where sprayed,	382	6
	Average where not sprayed,	221	56
	Gain from spraying,	161 bushels	

It is evident from these figures that as heretofore there was a large gain from the use of bordeaux mixture. These results are in agreement with those extending now over fifteen successive years. We have always found spraying a profitable procedure with early potatoes because of its effect in warding off insect attacks and early blight, aside from the general stimulation it affords to the plants. Evidence on these points secured this season is presented in this bulletin on pages 24-26. But the greatest gains have always been found with the later crop, i. e. vigorous main crop varieties planted in May and maturing in the autumn. The following table fairly presents the results obtained during fifteen years and furnishes such conclusive evidence as ought to emphasize the idea that *proper spraying pays.*

GAINS FROM USE OF BORDEAUX MIXTURE ON LATE POTATOES

Variety	Planted	Sprayed	Yield per acre		Gain per acre
			where sprayed	where not sprayed	
White Star	May —, 1891	Aug. 26, Sept. 8	313 bu.	248 bu	65 bu.
" "	May 20, 1892	July 30, Aug. 13, 25	291 "	99 "	192 "
" "	May 20, 1893	Aug. 1, 16, 29	338 "	114 "	224 "
" "	Apr. 26, 1894	June 16, July 17, Aug. 30	323 "	251 "	72 "
" "	May 20, 1895	July 25, Aug. 13, 31	389 "	219 "	170 "
Polaris	May 15, 1896	Aug. 7, 21	325 "	257 "	68 "
"	June 1, 1897	July 27, Aug. 17, 28	151 "	80 "	71 "
White Star	May 10, 1898	July 21, Aug. 10	238 "	112 "	126 "
Average, 3 varieties	May 18, 1899	July 26, Aug. 17, Sept. 8	229 "	161 "	68 "
Delaware	May 23, 1900	Aug. 4, 23	285 "	225 "	60 "
"	May 25, 1901	July 20, Aug. 21	170 "	54 "	116 "
"	May 15, 1902	Aug. 1, 20	298 "	164 "	134"
Green Mtn.	May 1, 1903	Aug. 10	361 "	237 "	124 "
Delaware	May 25, 1904	Aug. 1, Sept. 1	327 "	193 "	134 "
"	May 15, 1905	Aug. 2, 21	382 "	221 "	161 "
Average of 15 years			**295 "**	**176 "**	**119 "**

SPRAYING THE SOIL TO PREVENT THE ROT

Practically all of the potato rot which occurs in Vermont is due to the late blight fungus, and to the decay of the tubers which follows the development of the fungus on the foliage. Attention was called in a former report to the controversy which often arises as to whether tuber infection is due to the passage of the fungus down the blighting stems or whether it results from the washing or migration of the spores through the soil. The publication referred to reports upon trials designed to throw light upon this matter by spraying the surface of the ground with bordeaux mixture. The trials were repeated in 1905. The yields were as follows:

Soil sprayed. Sound tubers, 60.2 pounds; rotten tubers, 12.5 pounds.
No treatment. Sound tubers, 13.5 pounds; rotten tubers, 57.9 pounds.

Where no treatment was given, 81 percent rotted in the ground; where the soil was sprayed, only 17 percent rotted.

The data obtained in the similar trial of 1902 are pertinent here. The disease was not as severe then, but the outcome was as follows:

Soil sprayed. Sound tubers, 151 pounds; rotten tubers, 2.5 pounds.
No treatment. Sound tubers, 113 pounds; rotten tubers, 26 pounds.

When reduced to percents the 1902 results show 2 percent of rot where the soil was sprayed and 19 percent where it was not.

The results of the two trials are in general agreement, therefore, in showing not only that the disease passes from leaf to tuber, but that the main channel at least is through the soil rather than through the stem. This is in accord with the explanation of the habits of the fungus generally accepted by botanists, viz., that the tubers rot because of infection by spores developed on the foliage and thence find-

ing their way through the soil, largely by being washed there by rains. The fact that there was considerable rot this year in spite of the spraying appears to contradict the claim that *all* of the tuber infection is to be thus explained. Observations which are to be discussed later (pages 33-34) lead to the conclusion that there is some spread of the fungus from tuber to tuber in the soil. The conditions were favorable for this in the above experiment of 1905, but not so in 1902, and the difference in results is probably largely due to this fact. While soil spraying is not to be recommended in practice, it may be noted that in the later sprayings when the disease is bad and soil heavy it may pay to make extra heavy applications of the mixture, that enough may reach the soil and attack the fungus spores falling thereon.

SPRAYING AS A REMEDY FOR EARLY BLIGHT

The climatic conditions during the growing season of 1905 were in general sufficiently moist and cool to be generally favorable to the development of the potato, especially during the latter part of the summer. This resulted in less than the usual amount of early blight (*Alternaria solani*), which is a disease characteristic of hot, dry weather. The only exception observed was on the experimental field situated on the sand plain farm belonging to the University. The 1904 crop on this piece was practically a failure owing to early blight. Foreseeing a probable repetition of the trouble on the same field this year, a spraying experiment was planned to determine how far bordeaux mixture will check the disease under these conditions. While evidence has been secured in previous years that it will do so in some measure, difficulty has been experienced in formulating exact conclusions because of the usual complication of late blight or other troubles.

Details of experiment.—The soil is a light sandy loam recently cleared from pitch pine, and planted with potatoes in 1904 as well as the present year. The crop was planted June 9 in drills 40 inches apart, 15 inches between sets. There were thirty-six rows altogether, each 60 feet long, consisting of six rows of each of the following varieties: Rural New Yorker No. 2, Delaware, Green Mountain, Polaris, Early Rose and Early Ohio.

It will be noted that this series includes a representative set of standard varieties, ranging in season from the earliest like Early Ohio to medium late like the first three. The conditions proved ideal for the test of the question proposed. Owing to the lateness of planting and the favorable summer, all varieties alike continued their growth until well into the autumn. Moreover, there was during the last six weeks of their life a typical and severe development of the early blight

fungus upon the foliage, with practically no complication with other maladies such as late blight and tip-burn. The standard bordeaux-paris green mixture[1] was used on the sprayed rows and paris green and lime applied to the control rows. Upon one-third of the rows, two of each variety, the bordeaux-paris green mixture was applied five times, July 15 and 24, August 2, 18 and 28. Upon another third, only three applications were made, the second and fourth being omitted. The other two rows received three applications of paris green and lime.

Development of disease.—Leaf spots showing the presence of the early blight fungus were abundant upon the unsprayed plots before the middle of August, and by the last of the month, taking the average of all varieties, about one-half of the foliage was killed. The extent of the injury varied, however, in direct proportion to the natural earliness of the maturity of the variety, as will be seen by a glance at the following records of conditions on August 28:

DAMAGE FROM EARLY BLIGHT ON UNSPRAYED PLANTS

Variety	Foliage killed	Variety	Foliage killed
Rural New Yorker No. 2	15 percent	Polaris	50 percent
Delaware	25 "	Early Rose	75 "
Green Mountain	50 "	Early Ohio	90 "

There was an abundant sprinkling of early blight spots on the remaining unsprayed foliage of all varieties at this date and all the tops on the unsprayed rows died during the next fortnight.

The crop on the sprayed plots showed a striking contrast to these. There was a slight amount of early blight present on the plants sprayed three times, though not enough to have caused practical injury. Careful search revealed scarcely a spotted leaf on those sprayed five times. During the following fortnight there was a slight increase in the amount of this spotting on the plants sprayed three times, though not enough to be of practical consequence; while those sprayed five times remained almost without a spot until the end of the season. This came on September 13, when all were cut down by an early frost.

The yields were as follows in pounds per row:

	Sprayed 5 times	Sprayed 3 times	Not sprayed
Rural N. Y. No. 2,[1]	60	74	55
Delaware,	59	52	23
Green Mountain,	54	49	22
Polaris,	40	42	27
Early Rose,	64	42	12
Early Ohio,	54	57	30
Totals,	331	316	169

[1]6 pounds copper sulphate, 4 pounds lime, 40 gallons water, ½ pound paris green. The control rows were dusted with one part paris green in 15 parts air slaked lime.

[1]There was a large stump in these rows, which accounts for the relatively small gain shown where sprayed five times.

These figures are in complete accord with the verdict that had been reached from the appearance of the tops, viz.: that there was very decided gain from the spraying and that five applications are slightly better than three, but not enough so to be of consequence.

Discussion of results.—Judging from the appearance of the plants, we attribute considerable, perhaps nearly one-half, of the actual gain in yield to the beneficial effects of the bordeaux mixture in other ways than in checking the early blight fungus., i. e. in deterring insects from attacking the plants and in promoting their general vigor. Fully one-half was due to checking the early blight fungus. The foliage was practically free from the attacks of the late blight (*Phytophthora*) and there was no rot in any of these rows. It was therefore as complete a demonstration as could be desired of the efficacy of bordeaux mixture as a remedy for early blight, providing it is applied *thoroughly* and *in season.* We emphasize these points because few potato growers seem to realize sufficiently their importance.

II. RELATION OF DATE OF DIGGING TO DEVELOPMENT OF ROT

Investigation into this question in previous years has led to interesting conclusions of much practical significance. The conditions of the summer of 1905 were somewhat different from those when the previous trials were made, so it was thought desirable again to make trial diggings at different dates.

Details of experiment.—The soil was a heavy undrained clay loam, ill adapted to potato culture at best, and especially so in a wet season like that of 1905. The variety was State of Maine, planted about the middle of May. No fungicides were applied. The late blight fungus appeared on the foliage about the 20th of August and spread slowly but persistently until the middle of September, when substantially all the tops were dead. Owing to the frequent September rains this soil was wet practically throughout the month. This fact must be borne in mind in considering the results. Part of the tubers were dug on each of two dates, September 9 and October 7. These were in each case wet, with considerable soil clinging to them when dug. They were allowed to lie in the field a few hours to dry off, then stored in shallow boxes, well ventilated, in a dry cellar at a temperature of 50-55° F. There was some loss of weight attributable to the dirt which rattled off these tubers at the later weighings, but this was

essentially the same in all rows, and since the data give comparative rather than absolute values, this may be disregarded. The results as to total yields and subsequent rot are as follows:

DETAILS AS TO YIELDS AND DECAY WHEN DUG AT DIFFERENT DATES

Row No.	Date of Digging	Condition when dug				Condition Sept. 15				Condition Nov. 11.			
		Sound		Rotten		Sound		Rotten		Sound		Rotten	
		No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I	Sept. 9	580	88 lbs.	0	0 lbs.	560	78 lbs.	20	3.6 lbs.	440	56 lbs.	120	6.3 lbs.
II	Oct. 7	288	44.3 lbs.	250	38.5 lbs.	....	.....	....	.....	244	34.8 lbs.	44	4.3 lbs.
III	Sept. 9	558	88 lbs.	0	0 lbs.	498	74.4 lbs.	60	8.6 lbs.	333	43.2 lbs.	165	7.4 lbs.
IV	Oct. 7	214	31.5 lbs.	270	39.8 lbs.	....	.....	....	.....	194	25.8 lbs.	20	5.4 lbs.

Adding together the results from rows I and III and from II and IV respectively, the following figures are obtained:

Dates of Digging	Total amount when dug		Condition when dug				Final condition				Percent of crop saved	
			Sound		Rotten		Sound		Rotten			
	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	By no.	By weight
Sept. 9	1138	176 lbs.	1138	176 lbs.	0	0 lbs.	773	99 lbs.	365	54 lbs.	68%	56 %
Oct. 7	1022	154 lbs.	502	76 lbs.	520	78 lbs.	438	61 lbs.	584	88 lbs.	43%	40 %

Discussion of results.—The results are capable of but one interpretation. There was greater loss from the later digging than from the earlier. This is an outcome radically different from those of the previous trials extending through the three years 1902-04 and involving the averages from six fields and five varieties in 1902, one field and one variety in 1903, and one field and six varieties in 1904. In the light of these former results that of 1905 may be held to be the exception which may prove the general rule. Fortunately, observations, which will be discussed in detail later, were also made at digging time which explained the result. Suffice it to say here that it was found that owing to the excessive rain and the heavy soil the rot fungus (*Phytophthora*) was forming spores on the surface of many of the tubers during the latter part of September. This has never before been observed by us, and is probably an exceptional thing. Yet it is doubtless the fact that a considerable part of the rot which destroyed

the later dug tubers in the present field was the result of inoculation from such spores in the soil between the dates of the earlier and later diggings. Reviewing the details of our former results in the light of this conclusion, we are led to believe that a similar condition of affairs has only once before occurred, viz., in the south plot of Holt's field, 1902. The figures there show a loss from late digging about like the present and the soil conditions were similar, viz., a heavy wet clay loam. The rule which was formulated as the result of previous experiments was favorable to late digging where the rot is feared. We would now modify it by making an exception of heavy wet soil in a wet season. Of course every potato grower avoids such soil as unsuited to the crop anyhow, providing he has other soils available, so this exception really affects but a minor portion of the crop. While this is our conclusion to date, it is planned to continue these trials upon various soils and under varying conditions until no doubt remains.

III. RELATION OF STORAGE CONDITIONS TO DEVELOPMENT OF ROT IN POTATOES

Favorable opportunity was secured for making a number of experiments to determine the relation of storage conditions to the development of rot in potato tubers. For this purpose tubers were taken from the same field as in the preceding experiment. As explained, these were State of Maine potatoes and the soil was a heavy, moist, clay loam. The soil is poorly suited to potato growing in any season, and was especially so where there was much rain in late summer as in 1905. No fungicide was applied to the plants and the late blight developed considerably on the tops. The rains kept the soil so continually wet during September that much of it clung to the tubers at digging time. Every condition, therefore, favored a considerable development of rot in the storage cellar. With this expectation in mind, four questions were formulated: (1) Does liming prevent rot?; (2) Will disinfection with formalin lessen rot?; (3) Will sun-drying the tubers lessen rot?; (4) What is the relation of temperature of storage to rot?

DOES LIMING PREVENT ROT?

Results obtained during the last two years have given negative replies to this question. Since the conditions of the field just described promised an excessive loss from rot, it was decided to repeat the trial

once more. In order to test the lime more thoroughly it was decided to try it on both moist and dry tubers. Therefore two rows were selected. The digging was begun on the morning of a bright, clear day, and the tubers of the first row were dug early and allowed to dry thoroughly before taken to the cellar. Those of the second row were taken in while still moist, indeed almost wet, the ground being low and damp. No rotten potatoes were found in the first row at digging time, and only three in the second; but the occurrence of late blight on the tops, together with the soil conditions, made us confident that there would be a considerable rot in the tubers. When the tubers were placed in storage air-slaked lime was scattered over one-half of each lot, at the rate of a pound of lime to three bushels of potatoes. This sufficed to give the surface of each potato a liberal coating, and certainly is as much as anyone who has either to use or to attempt to sell the tubers would ever apply. All were stored in shallow boxes, well ventilated, in a dry cellar at a temperature of 50-55° F. They were sorted twice, first September 15, one week after storing, and again on November 11. The results follow:

Dry, limed,	35% of number,	52% of weight
Dry, no treatment,	23 "	36 "
Moist, limed,	50 "	61 "
Moist, no treatment,	40 "	54 "
Average, limed,	42.5 "	66.5 "
Average, no treatment,	31.5 "	45 "

It is evident, therefore, that instead of being an advantage in the preservation of the tubers, the lime appeared actually to favor the rot.

Discussion of results.—In the first place it would be well to compare these results with those of the preceding trials, taking the loss in weight as the basis of comparison.

In 1903,	loss where limed, 29%;	no treatment, 27%
In 1904,	loss where limed, 9%;	no treatment, 11%
In 1905,	loss where limed, 66%;	no treatment, 45%

In two years out of three, therefore, the loss from rot in the limed potatoes was actually greater than in the unlimed ones. It is hard to escape the conclusion, therefore, that instead of checking the rot, liming probably actually favors it. Certainly when one takes into consideration

the further fact that the lime coating makes the tubers disagreeable to handle and hard to prepare for cooking, it becomes evident that liming potatoes is to be condemned as worse than useless. The evidence so far as obtained by others favors this same conclusion.

WILL DISINFECTION OF TUBERS LESSEN ROT?

So far as is known to the writers this question has never been determined, unless the use of lime as described in the last experiment be considered a disinfecting process. Although it might not usually seem practicable to disinfect potatoes, even if there was some lessening of rot by some such process, yet one can conceive of conditions where such a procedure would be applicable, especially for growers of seed potatoes. Moreover, it is of considerable interest as contributing to the understanding of the time and mode of infection by the fungus.

Details of experiment.—The potatoes were left on the ground several hours after digging to sun-dry, and as they were gathered up they were carefully divided into two lots, one-half from each hill going into each lot. Lot I received no treatment; lot II was soaked for an hour in a solution of 8 ounces of Merck's formalin in 15 gallons of water, i. e. 0.4 percent solution, the same strength as used in disinfection against scab. These tubers were then spread upon the cellar bottom for twenty-four hours to dry. Both lots alike were stored in shallow wooden boxes, well ventilated, in a dry cellar held at a temperature of 50-55° F. The outcome was as follows:

Lot No.	Treatment before storing	Amounts stored		Sorted Sept. 15				Sorted Nov. 11			
				Sound		Rotten		Sound		Rotten	
		No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I	None	290	44 lbs.	280	39 lbs.	10	1.8 lbs.	220	28 lbs.	60	8.5 lbs.
II	Formalin	293	44 lbs.	272	38.1 lbs.	21	2.9 lbs.	231	29.5 lbs.	41	5.7 lbs.

From these figures it is evident that the formalin disinfection was without material effect in checking the rot. This result is the more noteworthy in view of the fact that these tubers had much of the clay soil clinging to them and that the untreated tubers were in a moist condition when stored.

RELATION OF MOISTURE TO ROT

The presumption is that tubers keep better if dried before storing. Since the soil was very wet at time of digging in one field where rot was feared, it was considered worth while to put this matter to the test. Accordingly, two rows were dug on a very bright sunny autumn day, favorable to quick and thorough drying. One-half of each hill was picked up promptly after digging while still moist and constituted the lots called *a*. The other half of each hill was left in the sun several hours and turned once meanwhile, thus securing pretty thorough sunning and drying of the surface; these constituted the lots called *b*. All were stored alike in a dry cellar in shallow, well ventilated boxes at 50-55° F. Very little rot was found in these at digging time, September 9, but as was expected, much developed in storage. The tubers were sorted twice with the following results:

Row No.	Condition when stored	Amounts stored		Sorted Sept. 15				Sorted Nov. 11			
				Sound		Rotten		Sound		Rotten	
		No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I a	Moist	279	44 lbs.	230	30.6 lbs.	49	8.5 lbs.	163	19.0 lbs.	67	7.9 lbs.
I b	Dry	306	44 lbs.	271	36.2 lbs.	35	4.1 lbs.	200	24.5 lbs.	70	9.4 lbs.
II a	Moist	335	55 lbs.	295	44.5 lbs.	40	6.3 lbs.	200	25.3 lbs.	105	13.8 lbs.
II b	Dry	349	55 lbs.	311	46.5 lbs.	38	5.4 lbs.	208	27.0 lbs.	108	15.0 lbs.

It is evident, therefore, that the results were more favorable where the tubers were stored dry, whether one considers number or weight of sound tubers on November 11. Averaging the two lots and reducing to a percentage basis the gain is as follows: Based on numbers of tubers, 62 percent of the crop was saved where stored dry as contrasted with 59 percent where stored moist. Based on weight of tubers, 52 percent was saved where stored dry as contrasted with 45 percent where stored moist. It is further noteworthy that the gain occurred, as one might naturally expect, during the first few days following storage; indeed, in the last period there was slightly more loss among those which were dried before storing. One is led to ask why this is so. Three possible explanations occur to us. First, it may be due to infection during storage, as shown later in this report; second, it may be that the moister conditions stimulate or favor a

more vigorous or destructive development of the fungus already in the tubers; third, it may be that the moister condition of the tubers keeps them in a condition permitting or favoring destructive invasion by the fungus. Whatever the explanation, the practical conclusion is the same, viz.: that potatoes should be allowed as much exposure to sun and air as practicable before storage, if rot is anticipated.

RELATION OF TEMPERATURE OF STORAGE TO DEVELOPMENT OF ROT

Everyone realizes the probable importance of this factor. Potatoes are, however, so little handled in cold storage in the regions where rot prevails that no exact records have been secured on this point so far as we know. The following trials were planned with this end in view:

Some six bushels of tubers were dug September 22 from the field already described and divided into three like portions. Each was placed in a barrel. The first was stored near the greenhouse boiler at a temperature approximating 70° F.; the second in a cellar at 50-55° F.; the third in a cold storage house at 40° F. The tubers of lots I and II were sorted twice, but to simplify the presentation only the conditions are shown as existing on Nov. 18, when last sorting was done:

Lot No.	Storage temperature	Amounts stored Sept. 22		Conditions Nov. 18				Percent of crop saved	
				Sound		Rotten			
		No.	Weight	No.	Weight	No.	Weight	By No.	By Weight
I	70	850	116 lbs.	275	36 lbs.	575	65 lbs.	32%	31 %
II	53	691	116 lbs.	352	54 lbs.	339	51 lbs.	51%	47 %
III	40	756	116 lbs.	650	96 lbs.	106	17 lbs.	86%	83 %

Discussion of results.—This outcome is one of the most interesting of the entire series and of much practical significance. Potatoes have sold in the Burlington market this year for 80 to 90 cents a bushel. There would have been an immense saving and a wide margin of profit if more potatoes had been placed in cold storage. While it may not prove practicable for the smaller growers to do this, it certainly behooves everyone to appreciate the importance of placing the crop in the coldest storage room available and as promptly as possible after digging, when much rot is anticipated. It is proposed later to trans-

fer to a warm room portions of these tubers which have been kept from rotting by cold storage. It is of practical interest to learn whether in such case further rot will develop in mid-winter.

IV. STUDIES AS TO THE TIME AND METHOD OF TUBER INFECTION BY THE ROT FUNGUS

This is a question of much practical importance and about which there is incomplete knowledge. It has generally been held by plant pathologists that it results from spores borne on the leaves and washed thence through the soil to the tubers. The results of our soil spraying experiments already described are in general agreement with this idea. Granting this, some practical questions remain unanswered:

Does the fungus spread from tuber to tuber in the soil?

Can such infection occur with fully mature tubers or only with the immature ones?

May tuber infection result from the contact of spore bearing tops with tubers at digging time?

Does the fungus spread from tuber to tuber in the soil? On a heavy moist clay practically all of the foliage was killed before the middle of the wet September of 1905. Meanwhile diggings made at various dates showed that the rot had begun to develop, a little being found on September 9, but the rapid spread not occurring until the last half of the month. Moreover, tubers dug at various times and places during this latter period showed the blight fungus growing abundantly and sporulating upon the surface of decaying tubers. Spores were also germinating in the adjacent soil. The fungus threads were found, moreover, ramifying through the soil from the surface of the rotting tubers and sporulating abundantly. Clearly the fungus was capable of spreading from tuber to tuber through the soil. This apparently explains the rapid increase in rot occurring in late September after the foliage was dead. In the light of previous experience, however, it seems likely that such rapid and destructive spread in the soil occurs only on wet heavy lands. Further observation is needed on this point, owing to its practical importance.

May infection of mature tubers occur by contact with blighting tops at digging time? To test this a lot of potatoes dug from the above mentioned field on September 9 were divided into three portions. One lot was placed at once in storage, the other two were each kept in a moist tub for a day, the tubers in one tub being covered merely

with moistened burlap, while those in the other were covered with freshly-cut potato tops bearing an abundance of the blight fungus. These latter were therefore exposed to infection from the fungus spores if capable of it at this stage. Moreover, as the tubers were removed from the tubs at the end of this period one-half of those so infected were washed under the garden hose to rid them of all dirt, while the other half were placed in storage in a decidedly muddy condition, just as dug. All were kept in like storage in ventilated shallow boxes in a dry cellar at a temperature of 50-55° F. They were sorted twice. The relative loss was 92 percent where infected and not washed, 100 percent where infected and washed, 77 percent where not infected but kept moist for thirty-six hours, and 54 percent where stored at once without any treatment. There can be no doubt from these figures as to the possibility of tuber infection at digging time, provided conditions are sufficiently favorable, i. e., an abundance of spores and moist conditions.

Does the fungus spread from tuber to tuber during storage? Experimental studies bearing on this were made as follows: First, it was found that tubers showing the dry rot in storage in October were bearing an abundant crop of the fungus heavily loaded with spores. These were in shallow boxes in a dry cool storage room, and it hardly seems possible that these spores could infect other tubers under those circumstances. There is reason to think that if in deep bins, where moisture conditions permitted, these spores would germinate. To test the possibilities of tuber infection under such circumstances at this time (late October) sound tubers were taken into the laboratory and infection secured by seeding them with spores while in a moist chamber.

There can be no doubt, therefore, as to the possibility of infection of tubers in storage. Probably many tubers are so infected during the first fortnight after digging where there is much moisture and a high storage temperature, say above 60°F. It is not thought that there is enough danger to be of practical moment, however, providing the tubers are dry when placed in storage and kept continuously dry and cool during the first month thereafter.

LETTUCE CULTURE

FLAT GROWN VERSUS BENCH GROWN PLANTS

The usual practice of market gardeners in this vicinity is to grow lettuce rather close together in the greenhouse bench, say from four to six inches apart, and when about two-thirds grown to transplant to flats or boxes averaging 12x15 to 14x20 inches in surface area, and containing from one to two dozen plants. This rather unusual practice is the result of a preference on the part of the dealers thus to handle open head or curly lettuce. The grower receives forty cents per dozen for plants thus raised.

The object of the present trial was to determine whether it was feasible to grow the plants in flats, from the time of transplanting to the bench till ready for market, and, if so, whether relatively as good returns could be secured. The flats used were especially constructed

Results.—The plants in the flats, owing to their crowded condition, were ready for market possibly a week in advance of those in the bench; but, as will be noted, they were very inferior in size. The relative size of the average lettuce grown in flats and the bench were about three and seven ounces respectively. Notwithstanding the smallness of the flat grown plants, they nevertheless presented a good appearance in the flat and sold readily at forty cents, while those grown in the bench commanded but fifty cents.

Profit.—It is obvious that while the product of the flats was much inferior to that of the bench, the profit from them was much greater from a given area. The box flat containing a dozen plants occupying a surface area of about 13x17 inches, while the dozen bench grown plants occupied 24x32 inches; or, relatively speaking, about as 1 to 3.5. Expressed in terms of dollars and cents per area occupied, the returns per square foot were twenty-six cents from the flat grown plants as against less than ten cents from the bench grown ones. These results show under existing conditions of marketing a very decided advantage in favor of closer planting in the bench. Where the quality rather than the number of plants is the goal, these differences would not be so great; in fact, the bench grown plants ought to and might prove the more profitable with a fancy trade. Likewise in markets where the crop is sold by weight the larger and heavier lettuce would very nearly equal the lighter but more closely grown plants.

Conclusions.—The investigations above outlined seem to warrant the following deductions:

1. Under the local market conditions a greater net profit may be secured from closely planted lettuce than from that given sufficient space to develop into full sized plants.

2. The growing of plants in flats to maturity, or, at least, to saleable size, is a feasible proposition and lessens the labor of lifting the plants and resetting in flats previous to marketing.

3. It is not possible to grow as heavy or as good lettuce by close planting as by allowing enough space for the crop's best development.

COMBINATION INDOOR AND OUTDOOR LETTUCE CULTURE

The local consumption of head lettuce is considerable during the winter and spring season, in fact, during all but the height of the summer season; yet the market gardeners of this section do not attempt to grow it, the supply being all obtained from Boston commission houses. This is largely due to lack of suitable soil, and to some extent, no doubt, to failure on their part properly to appreciate the cultural requirements of the lettuce crop, which, if not complied with, is apt to induce functional derangement of the plant, as usually evidenced by tip-burn. An invasion of fungi and bacteria usually follows the collapse of the cell tissues by tip-burn, which soon destroys the plant. Owing to these conditions the head lettuce crop has never proved a financial success with such local growers as have attempted it, although it commands double the price of curly leaved open heads.

The unusually fine development in 1903 of head lettuce which had been started in the station greenhouse and transplanted to the open ground as soon as favorable weather obtained, suggested to the writer a method of lettuce culture, whereby plants, started early, either in the greenhouse, hotbed or coldframe, could be transplanted to open ground as soon as weather permitted, with every prospect of producing a fine quality of head lettuce, which, though somewhat late in the season, would still sell readily at fair prices. While the plan is not a new one, it seems not to have been practiced here with head lettuce.

Varieties grown in 1904.—The following varieties of lettuce were grown in this way: Deacon, Big Boston, May King, Black Seeded Tennisball, Market Gardener's Private Stock, Iceberg and Improved Hanson; the last two being curly leaved varieties, but under proper cultural conditions forming good heads. The plants were started in the greenhouse, transplanted into flats and hardened off in the coldframes They were set in the open ground in rows 15 inches apart and about 10 inches apart in the row.

Average weight of plants.—When the majority of the plants had arrived at their best development, all were cut and weighed. The average weight of ten plants of each variety was as follows:

	Av. weight in grams	Av. weight in ounces
Deacon,	550	19.4
Big Boston,	377	13.3
May King,	312	11.0
Black Seeded Tennisball,	432	15.2
Market Gardener's Private Stock,	532	18.8
Iceberg,	778	27.4
Improved Hanson,	601	21.2

The average weight of each variety was found to be:

	Grams	Ounces
Deacon, 26 plants,	562	19.8
Big Boston, 9 plants,	633	22.3
New York Cabbage, 39 plants,	853	30.0
Iceberg, 75 plants,	944	33.3
Improved Hanson, 15 plants,	894	31.5
Grand Rapids, 24 plants,	745	26.3

The results show in most cases a marked increase in size of plants over those of the preceding season. This may be accounted for by a more favorable growing season. Given in order of merit, they are as follows: Iceberg, New York Cabbage, Improved Hanson, Grand Rapids and Big Boston. Improved Hanson was much superior to the previous season, heading up more firmly and producing a large amount of well blanched lettuce. Iceberg again produced the heaviest heads of any on trial. The largest individual heads weighed:

	Grams	Ounces
Iceberg,	1325	47
Improved Hanson,	1207	43
New York Cabbage,	1160	41
Grand Rapids,	995	35
Big Boston,	825	29
Deacon,	790	28

This crop sold readily at seventy-five cents per dozen, and in quality and size greatly exceeded that of any shipped head lettuce. The plants were grown in a fairly rich garden soil and received as fertilizer only a moderate application of manure previous to plowing the land. The soil was a rather fine, gravelly loam, well drained and fairly retentive of moisture. The labor involved in growing the plants up to the time of transplanting to the field was slight.

SOIL STERILIZATION

Soil sterilization ranks as one of the most important of the more recent developments of greenhouse technique. On account of the severe injury so frequently caused by nematodes to tomatoes and cucumbers when grown under glass, the sterilization of greenhouse soil has almost become a necessity when the soil is thus infested.

The serious nematode injury suffered by a crop of tomatoes grown in the station greenhouse in the winter of 1902-03 showed that the winter forcing of tomatoes and cucumbers could not be successfully accomplished there unless the soil was sterilized. Since the larger portion of the space devoted to these crops was occupied by solid beds, it was thought desirable to attempt sterilizing this soil in place. Three-inch drain tiles were sunk about ten inches below the surface of the soil. The lines of tile were laid every sixteen inches, each line being independent of every other, and connected with the surface by a vertical section of drain tile. The ends of each line of tile were plugged with paper and soil. The upright was connected with the laterals by a hole drilled through the upper surface of the end tile over which it was securely cemented. The verticals were connected alternately at one end or the other of the laterals, thus permitting the live steam to be injected at opposite sides of the bed, and thus equalizing the diffusion of heat throughout the soil. Not only were the tile joints open, but each section of tile was perforated with a quarter to a half-inch hole through each side, the better to facilitate the escape of the steam. Under a pressure of from 40 to 60 pounds of steam, a section of bed containing a surface area of nearly seventy square feet could be heated up to about 210° F. in approximately three hours' time. The surface of the soil being well covered with burlap, this temperature was maintained for a considerable period. In one case noted the thermometer stood at about 130° F. twenty-four hours after treatment. This procedure proved in every case an effective remedy against nematodes and obviated the labor involved in treating the soil in a box or other specially constructed device. The tile once placed lie so deep that they need not be molested in digging over the beds or in changing the soil, and are always ready for use in subsequent treatments of new soil. Then, too, the surface connection by means of vertical sections afforded ideal soil aeration.

STERILIZING SOIL IN SUB-WATERED BENCHES

Since nearly two hundred square feet of bench surface in one of the greenhouse rooms was fitted up for sub-watering by means of galvanized iron pans and layers of porous bricks, the question arose as to whether it was feasible to sterilize the soil in these benches by injecting steam into the pan through the watering tube. A thorough trial

of this scheme showed that while it was possible thus to sterilize soil it could hardly be called a practical method, as it took too much steam to do it. It was found that the injection of steam into a pan full of cold porous bricks resulted in a very considerable condensation of water, in fact, almost to the point of complete saturation of bricks and soil. In view of this experience it would seem to be more economical to employ a sterilization box for the treatment of soil in sub-watered benches.

Conclusions.—These trials indicate:

1. That sterilization of soil in a solid bed, using drain tiles as steam conduits, is both practical and feasible, and involves less labor while employing possibly a greater volume of steam.

2. That sterilization of soil in place in a sub-watered bed is not a desirable practice.

ON THE WINTER INJURY OF APPLE TREES

Mention of an injury to apple trees during the winter of 1903-04 was made in the last annual report. After the trees had blossomed and partially leaved out, growth was arrested and the partly unfolded leaves shrivelled and died. A little later in the season many of these trees pushed out new growths at the base of the scaffold limbs or somewhat higher up. This unusual occurrence was generally ascribed to winter injury of the roots; but continued observation of trees thus affected leads the writer to believe that some of the injury may have been due to severe freezing of the tops.

Pruning experiments undertaken with a view of bettering the condition of these trees were inaugurated in early June. In an orchard where a number of eight-year-old Rhode Island Greenings were severely injured, some of the trees were severely pruned back after the secondary buds had pushed out new growths, others were somewhat less vigorously handled, while yet others were left untouched. It was thought that the severe pruning of trees on which new growths were being pushed out at the base of the limbs would tend to throw all the strength of the tree into a few branches, thereby securing during the first season a more vigorous development and a more shapely head.

Cultural treatment of orchard land.—Unfortunately the cultural treatment of the orchard, which was not under the writer's control, was not such as to secure a healthy development of the trees. A crop of oats was grown in 1904 and the land seeded down to grass; a hay crop was removed in 1905. It is not to be wondered at that winter injury occurred with such treatment of a young orchard; indeed, there is every evidence that the trees were in an unhealthy condition previous to the severe winters of 1902-03 and 1903-04. Hence the trees have not grown as they should have done had they received good culture.

Results.—Photographs were made of the injured trees both before and after pruning June 9, again on August 15 of the same season, and a final set were made on September 27 of the present season. A careful study of this series of photographs affords little evidence that pruning was beneficial. A comparison of one set would show a decided advantage in favor of pruning, while that of another set was equally favorable to the unpruned.

Conclusions.—While no very sweeping conclusions can be formed from a single experiment, conducted on a rather small scale and under unfavorable conditions, this much may at least be said:

(1) That in cases of winter injury like that mentioned above there is practically nothing to be gained by the hasty removal of the greater portion of the head of the tree; that, in other words, severe pruning is inadvisable and is probably more often injurious than beneficial.

(2) That in the light of the observations made it would seem advisable to defer pruning operations to the latter part of the growing season or possibly until the following spring.

(3) That whenever pruning is to be done no more branches should be removed than needed to preserve the balance of the tree top.

(4) That winter injury could be avoided by keeping the tree in a thrifty, vigorous condition. Weak, unhealthy trees are less able to stand extremes of temperature than thrifty ones.

INFLUENCE OF STOCK ON SCION

The reciprocal influence of stock on scion has long been an interesting subject of speculation and controversy, and is by no means settled at the present time. In order to study this reciprocal influence in plum propagation, five distinct classes of plums were grafted in 1899 on four as distinct types of stocks, as follows:

Stocks	Scions
Americana	Stoddard of the Americana group.
Wayland	Green Gage of the Domestica group.
Marianna	Chabot of the Japanese group.
Peach	Milton of the Wild Goose group.
	Newman of the Chicasaw group.

The earlier results of this experiment as reported by Waugh showed that Stoddard (Americana) did best on Americana stock; that Green Gage (Domestica) did best on Wayland stock, though the superiority was slight; that Chabot (Japanese) did almost equally well on Wayland, Americana and Marianna, with preference in the order given; that Milton (Wild Goose) did unusually well on Marianna, Wayland and American in the order named; that Newman (Chicasaw) did about equally well on all but Peach, on which none seemed to succeed

very well. These deductions were based on measurements of growth of a considerable number of trees grown in nursery rows.

To continue these observations on growth for a longer period of time, three trees of each variety upon each stock were planted out in the station orchard. The present report is based upon data obtained from these trees, October, 1905. This consisted in taking the diameters of the tree trunks at the collar and one foot above and also taking into account the general growth of the tree. The deductions made from the data obtained are as follows: Americana seems best for Americana; Wayland for the Japanese; Marianna for Milton, with little choice between Wayland and Marianna for the Domestica group; and no marked choice between any of the four stocks for the Chicasaw group.

INFLUENCE OF STOCK IN CHANGING HABIT OF GROWTH

In connection with the reciprocal action as affecting the rate of growth of the tree, a peculiar influence was noted by Waugh regarding the changed habit of growth of Milton on Marianna as contrasted by its growth on Wayland and Americana stocks. He characterizes these differences as follows: "The trees of this variety growing on Wayland roots are upright, narrowly vase-form, with relatively few large branches. . . . . On Marianna roots, the trees are low, round-headed, bushy, with thick spreading-drooping tops, much like trees of Marianna. If anything they exaggerate the typical character of the Marianna head. Moreover, the leaves are several shades darker and glossier and the twigs are dark red instead of being green, as in trees of the same variety growing on Wayland roots." At the present time the difference in color of foliage and bark are not noticeable, neither is the "upright narrowly vase-form" head of Milton on Wayland as pronounced; yet there is still a marked difference in the habit of growth of the trees upon Wayland and Marianna stocks. On Wayland the habit of growth is more or less upright, whereas on Marianna the head is low, bushy and spreading. Doubtless as the trees grow older these differences will become less marked.

NEWMAN ON PEACH STOCK

The seeming greater affinity exhibited by Newman on Peach stock over that of the other groups grafted upon it suggested an examination of the roots to see if Newman scions on Peach stocks might not possibly have sent out roots of their own and therefore virtually growing on their own roots. This was not found to be the case, as is shown in cuts where Newman on Peach roots is compared with those on Amerocana, Wayland and Marianna.

SUSCEPTIBILITY TO "PLUM POCKET" OR "LEAF CURL"

When pruning trees growing upon different stocks in 1903, it was apparent to the casual observer that the Milton trees on Marianna stock were much more seriously affected with "Plum Pocket" than were those of the same variety on Wayland or Americana. The same observation was also made in the spring of 1904. Whether the greater prevalence of plum pocket upon these particular trees was accidental rather than due to greater susceptibility is, of course, rather a difficult question to answer, but from the fact that greater infection was noted both seasons, it would seem to indicate some predisposition to the disease. This predisposition may be an inherent one, or, as seems more probable, the tree may be rendered more susceptible through external causes. For example, the habit of growth of the tree—low, spreading and bushy—would naturally furnish more favorable conditions for the lodgment and germination of the fungus spores than would the more upright, open-headed tree. Granting this assumption to be tenable, the stock is only an indirect cause of greater susceptibility.

MISCELLANEOUS FRUIT NOTES

During the past three seasons more or less extended notes and observations have been made on the fruit trees growing in the station orchard. These have had to do mainly with a study of the flowering and fruiting periods of plums and cherries, the data being taken partly for station purposes and partly for the use of the Division of Pomology of the United States Department of Agriculture.

While the observations are by no means complete, they are in some respects sufficiently so to permit of some comparisons as to dates of flowering and of ripe fruit during the past three seasons,—1903 to 1905 inclusive.

Summary.—A careful study of the data presented shows that there is a close relationship between time of flowering and time of fruiting, this relationship being quite uniformly maintained during the three seasons noted.

Desirable varieties.—The following varieties upon which observations have been made either in the station orchards or elsewhere, are deemed most desirable, the judgment being based upon hardiness, prolificacy and quality:

Plums.—Lombard and Arctic (*Moore's*) (Domestica), Burbank and Abundance (Japanese), Milton, Whitaker and Wooten (Wild Goose), Stoddard, Cheney and Hawkeye (Americana).

Cherries—Early Richmond, English Morello, Brusseler Braune, Wragg and Bessarabian.

INSECTS OF THE YEAR

Although there was no serious outbreak of injurious insects during the present season, a considerable number of inquiries were received concerning leaf eating and sucking insects. For the most part these inquiries were accompanied by living specimens, and when caterpillars or worms were sent, the query was frequent as to the likelihood of their proving to be the larvæ of the brown tail or gypsy moths. No authenticated cases of the presence of either of these two insect pests have been reported to the Station, and it is doubtful if either has as yet invaded the State. It is desirable, however, that all who are in doubt regarding the identity of any unfamiliar pest should send specimens to the Station for examination. The devastation wrought by these moths in Massachusetts should incite all residents of Vermont to take such precautionary measures as are practicable to guard against their introduction within our borders, a contingency which in the case of the brown tail is far from being remote.

Many specimens of the red-humped apple worm (*Oedemasia concinna*) were received. Others sent in more or less frequently were the yellow-necked apple tree worm (*Datana ministra*); a species of Halisodota; oyster-shell bark-louse (*Mytilaspis pomorum*); wooly aphis (*Schizoneura sp.*) and plant lice. Another insect not reported, the apple leaf miner (*Tischeria malifoliella Clem.*) was found in abundance in one of the Station orchards.

The *red-humped apple worm* has been quite abundant during the present season. It is easily recognized by its coral-red head and similarly colored hump on the back of its first abdominal segment. As a rule these insects are not considered a dangerous orchard pest, although when present in large numbers they do a considerable amount of injury. The usual remedies against leaf-eating insects, —spraying with arsenical poison—will serve to keep them in check.

The *yellow-necked apple tree worm* has not been generally distributed over the State or to have done any considerable damage to either fruit or forest trees. Like the red-humped apple worm, the larvæ feed in colonies, are very voracious, and when present in sufficient numbers cause considerable injury to the tree. It may be as successfully combatted with arsenites as is its red-humped fellow.

The larvæ of the *Halisodota* were clothed with dense tufts of finely-barbed white hairs. They were rather small, about one-half inch in length, and were generally sent in under the apprehension that they were larvæ either of the brown tail or of the gypsy moth. So far as known these insects have never occurred in sufficient num-

bers to prove troublesome to fruit or shade trees. They may be controlled in the same manner as the first two mentioned.

The *wooly aphis* has been more often found on young apple trees than elsewhere. They occur on the tips of young shoots, in crevices in the bark of the trunk, or in the scars caused by pruning. In such places they congregate in colonies. Their feeding habits in many respects are very similar to those of the ordinary plant lice from which they differ mainly in that they are covered with a light ash-grey wooly-like substance. When present in large numbers they undoubtedly cause much injury to the young fruit trees. As they are sucking and not chewing insects, the remedies to be employed are entirely different from that cited above. Contact insecticides like kerosene emulsion, tobacco liquid, whale-oil soap, etc., are the only effective methods of combating this class of pests.

The wide distribution of the *oyster-shell bark louse* has been noted in a former publication which has long been out of print, in which a somewhat complete account of its life history and habits is given and methods of controlling it discussed. Specimens are so frequently received and it is so generally prevalent throughout the State, that additional attention seems worth while.

The injury occasioned by the oyster-shell bark louse is, of course, directly proportional to its numbers. When trees are badly infested the drain made by these sucking insects upon the tree is a serious one, and may often result in its death. The oyster-shell bark louse is readily distinguishable from other scale insects by its elongated, rather slender curved form, being about one-eighth inch in length.

Remedies.—Two courses may be pursued in its eradication,—the scales may be attacked during the dormancy of the tree, or the newly-hatched larvæ may be dealt with while the tree is in full leaf. Treatment by the first method necessitates the application of an insecticide having sufficient caustic properties to destroy the eggs beneath the scales; that by the latter scheme is less drastic in that the newly-hatched larvæ, unprotected by a scale, are easily injured by more dilute caustic substances.

The most effective insecticide yet employed against the oyster-shell bark louse during the dormant period of the tree is the lime-sulphur, or lime-sulphur-salt wash. An application of this wash during the latter part of March or first weeks in April, followed in the case of badly infested trees by a second application before the buds have swollen much, will generally suffice to eradicate the scale. Such treatment is also effective in destroying the apple scab fungus spores.

Oyster-shell bark louse

The larvæ of the oyster-shell bark louse usually hatch out in this latitude about the first week in June. The newly-hatched insect appears as a small grey or brownish-grey speck on the surface of the bark, and is not readily recognized by the unaided eye as a living organism. When in this stage of their development, or even a little later, an application of kerosene emulsion diluted to one part to fifteen of water, proves quite effective, and, if properly made, can be applied even to the small twigs without fear of leaf injury.

The *apple leaf miner* was found in immense numbers in some old apple trees of one of the station orchards. A somewhat careful survey of the entire orchard showed that with few exceptions practically every leaf was infested with the larvæ of this insect. How they came to be so abundant the present season without having been previously noted, the writer is unable to say.

As a rule this apple leaf miner is not considered a serious pest. It is known to occur on the apple, crab apple, raspberry and blackberry. So far as the writer is aware, there is but one record of its having occasioned serious injury to cultivated fruits. Lyons reports them as causing serious damage to a blackberry plantation. The injury to the infested trees in the station orchard was quite marked. It was evidenced by the unhealthy appearance of the foliage, its premature loss,—the leaves falling from two to three weeks earlier than they normally should—and by the lack of development of the fruit, both in size and quality.

As this insect seems not to have been reported by the fruit growers of the State, it would be interesting to know whether any such leaf injury has been observed. The following brief description of the insect may serve as a guide to its detection another year: The larvæ when full grown are about one-fourth of an inch in length and about one-sixteenth of an inch in diameter, tapering gently from the head to the anal extremity. They are footless and of a light yellowish green

color with a brownish-black head. The newly-hatched larvæ tunnels its way between the two epidermal layers of the leaf, eating away the soft connective tissue, making a sort of thread-like passage at first which it gradually enlarges into a sort of trumpet-shaped mine. Owing to this characteristic shape it is sometimes called the trumpet leaf-miner. Very frequently the mines are greatly enlarged and when many miners are present in a single leaf the mines fuse into one another, thereby practically involving the whole connective tissue of the leaf. When fully developed the larvæ begins to pull in the opposite edges of the mine until it causes a fold in the leaf, after which the tiny cavity is well lined with silk preparatory to the transformation to the pupal stage. It passes the winter in the leaf and emerges in May as a small grey moth, measuring a little over a quarter of an inch from tip to tip. The moths soon mate and the female begins depositing its eggs, thus completing its life cycle.

Remedies.—As the larvæ work beneath the epidermis of the leaf they are not amenable to insecticidal treatment, either with arsenical or caustic solutions; hence such measures as may be employed for their suppression must be preventive rather than remedial. Lyons mentions picking off and destroying infested blackberry leaves, and the destruction of all fallen leaves, but makes no further report of the efficacy of this treatment. The destruction of the fallen leaves from infested trees or brambles, whenever it occurs in considerable numbers, seems to be the only feasible plan of controlling this insect.

CONCERNING MAPLE PRODUCTS

A technical article dealing with the detection of the adulteration of maple goods, appearing on pages 315-339 of the report, contains a few matters which are of general interest. The severely technical matter has no place in this bulletin and is omitted.

Characteristics of maple syrups from different sections.—The general characteristics of maple syrups from different sections of the sugar producing areas that have come under the writer's notice may be thus briefly described. Remarks refer to average quality goods:

Pennsylvania: Sweet and flat (often like molasses); maple flavor.
Ohio: Mild, delicate almost to flatness; maple flavor.
New York: Strong; maple flavor.
Vermont: Mild, delicate; good maple flavor.
Canada: Good maple flavor. Bulk of product dark in color, with strong flavor, occasioned by demand.

As far as marketable differences go, there is but small choice between Vermont, New York and Canadian goods of equal grade.

Density.—Standard maple syrup should weigh eleven pounds to the gallon. It should boil at a temperature of 218 to 219° F. and at ordinary temperature give a reading with the Baumé hydrometer of 35.5 to 36 degrees, corresponding to a specific gravity of about 1.325. A syrup giving a Baumé reading of 31 degrees at the boiling point will when cool generally show the standard reading of 36 degrees.

Maple syrup in bulk is usually purchased on a basis of an agreed price per standard gallon. This price, depending as it does on supply, demand and quality, has varied in the past few years from 60 to 80 cents a gallon. As a large percentage of the syrup as originally made weighs less than the eleven pound standard, proportionately less per gallon should be paid for the lighter syrup.

The following table has been prepared to be used in calculating payments: To facilitate the operation the prices covering Baumé readings from 30 to 36° for standard syrup at 70, 65 and 60 cents a gallon have been calculated.

	Baume	Factor	Price per gallon in cents		
Standard 11 pound syrup.....	36	1.000	70	65	60
	35	.972	68	63	58.5
	34	.944	66	61.5	56.5
	33	.917	64	59.5	55
	32	.889	62	58	53.5
	31	.861	60	56	51.5
	30	.833	58	54	50

Example.—If 65 cents a gallon is to be paid for 11 pound syrup testing 36° Baumé, how much should be paid for 880 pounds of syrup testing 32° Baumé?

Divide the weight of the syrup by 11 to get the number of standard gallons. Multiply the price paid for 11 pound syrup by the factor opposite the Baumé reading of the syrup in question. This gives the price to be paid per standard gallon. The number of standard gallons multiplied by the price per gallon equals the amount to be paid.

Thus: $880 \div 11 = 80$ standard gallons.

$65 \text{ cents} \times .889 = 58 \text{ cents}$.

$80 \times 58 \text{ cents} = \$46.40$, price to be paid.

THE INFLUENCE OF CHANGES IN FEEDING UPON MILK PRODUCTION

Feeding trials with cows have been a prominent feature at this Station since 1888. During the last decade the general plan of their conduct has been a fairly consistent one. From forty to sixty cows yearly have been kept under careful observation during the five to seven months of their fall, winter and spring barn life, under conditions which have permitted the reasonably accurate measurement of the values of a great variety of rations, of feeding stuffs and of feeding practices. The immediate results of the sundry trials have been detailed in the several annual reports. The large volume of

data which has accumulated lends itself readily to collation and to further calculation as to the effect upon production, not of this, that, or the other ration or feed, but of total and digestible nutrients, of digestible protein, carbohydrates and of calories of energy.

The data used are calculated from those published in the appendices of the tenth to the sixteenth reports inclusive. They comprise the records of 347 cows fed from three to seven months in feeding periods of from four to six weeks' duration. It hardly need be said that it would be useless to print the mass of individual data and that it would consume much space. The condensed data is shown on 16 pages in the report and indicates the results:

(a) When rations were unchanged;
(b) Ditto; more than 15.5 pounds of digestible dry matter;
(c) Ditto; less than 15.5 pounds of digestible dry matter;
(d) Ditto; varying from those carrying more to those carrying less than 15.5 pounds of digestible dry matter;
(e) When rations were changed;
(f) Ditto; more than 15.5 pounds of digestible dry matter;
(g) Ditto; less than 15.5 pounds of digestible dry matter;
(h) Ditto; varying from those carrying more to those carrying less than 15.5 pounds of digestible dry matter.

TABULAR STATEMENT SHOWING THE GENERAL CHARACTER OF THE TABLES ON PAGES 346-361 OF THE REPORT

Table number	Ration changed?	More or less than 15.5 lbs. of digestible dry matter fed	Total dry matter changed? / Digestible dry matter changed?	Digestible protein changed?	Digestible carbohydrates changed? / Calories changed?	Nutritive ratio changed?	Number of comparisons
I	no	.....	no	no	no	no	19
II	no	more	"	"	"	"	68
III	no	less	"	"	"	"	15
IV	yes	more	"	"	"	"	85
V	yes	less	"	decreased	"	widened	10
VI	no	.....	increased	no	increased	"	13
VII	yes	.....	"	"	"	"	6
VIII	no	.....	decreased	"	decreased	narrowed	121
IX	yes	.....	"	"	"	"	13
X	no	.....	no	increased	no	"	20
XI	yes	.....	"	"	"	"	20
XII	no	.....	"	decreased	"	widened	11
XIII	yes	.....	"	"	"	"	8
XIV	no	.....	increased	increased	increased	narrowed	45
XV	yes	.....	"	"	"	"	143
XVI	yes	less	"	"	"	"	18
XVII	yes	from less to more	"	"	"	"	38
XVIII	no	more	"	"	"	"	52
XIX	yes	"	"	"	"	"	178
XX	no	.....	decreased	decreased	decreased	no	70
XXI	yes	.....	"	"	"	widened	217
XXII	yes	less	"	"	"	no	22
XXIII	no	from more to less	"	"	"	"	9
XXIV	yes	"	"	"	"	widened	50
XXV	no	more	"	"	"	no	89
XXVI	yes	more	"	"	"	widened	255
XXVII	yes	.....	increased	"	increased	"	29
XXVIII	no	.....	decreased	increased	decreased	narrowed	8
XXIX	yes	.....	"	"	"	"	68

WHAT ARE THE TEACHINGS OF THESE CONCENTRATED DATA?

I. *As regards quality of milk.*—In only four out of twenty-nine comparisons was there a 2 percent change in the quality of the milk; and in but one case did the gain in quality exceed 0.10 percent fat. The thesis that under normal conditions food changes do not affect the fat content of the milk has now become so thoroughly established as to need no further argument; yet such a weight of testimony as is here gathered has seldom been adduced; and hence the emphasis.

II. *As regards the relationship of food consumption and milk production.*—Tables I to IV represent in three cases identical rations, and in the fourth different ones; but in all cases the cows ate in each of the compared periods a close approximation to the same amounts of total dry matter, of digestible dry matter and of the sundry nutrients, and ingested the same numbers of calories of energy. Lactation shrinkage being allowed for the differences in outcome expressed as percentages should be nil. They should be notably less than in any of the remaining twenty-five cases where more or less decided variations in food consumption of some sort were made. And so they are! Of the 24 figures expressive of food consumption 7 are zeros, 13 are ones, 2 are twos and 2 are threes. Of the 32 having to do with production, 12 are zeros, 12 are ones, 5 are twos, 2 are threes and 1 a four, an average value of one, a figure far below any other occurring in the entire twenty-nine tables. This comparison affords a good check as to the experimental error involved, for the reason just cited, that no such production figures occur elsewhere in the tables.

COST

The cost of the rations was calculated from assumed prices for hay and silage ($10 and $3 respectively) and market prices for grain feeds. It is well understood that cost and food value show no necessary parallelism. It is this fact which in part explains some of the apparent anomalies in the tabular matter and in the subjoined statements as to the relationship of cost and nutrient supply. The following points, however, seem fairly clear:

1. When similar amounts of nutrients were fed the cost of the ration was essentially unaltered.

2. When the supply of nutrients was somewhat increased—protein but slightly—the cost was unaltered; when increased—protein being most affected—the cost was somewhat advanced; when considerably increased—and protein greatly so—the cost was considerably enhanced.

3. When the supply of nutrients was somewhat decreased—protein but slightly—the cost was essentially unaltered; when consider-

ably decreased—and protein greatly so—the cost was somewhat lessened.

4. When the supply of nutrients was unchanged, other than protein, which increased, there was a slight increase in cost; when it remained the same, save protein which decreased, there was a sharp fall in cost in two cases and a gain in one in which the protein shortage was but slight.

5. When all nutrients but protein increased, so did cost; when all but protein decreased, cost remained stationary or advanced; when all nutrients increased but protein, which decreased, or *vice versa*, cost fluctuations were but slight.

6. Speaking broadly, the more was fed the more the ration cost and *vice versa*, regardless of the quality of the ration, i. e. its protein content. Yet this often plays an important part. When the protein plus or minus is 10 percent or more there is a larger proportion of sizable variations in cost than when they are less than 10 percent.

GENERALIZATIONS

In the attempt to generalize, one may hazard the following statements based on the tabular matter as shown in the report:

1. The testimony afforded by the results as between different rations and the same ration fed in different amounts is so nearly alike, speaking broadly, that one may safely group them together and argue on the basis of variations in dry matter or in nutrient consumption regardless of their origin.

2. When like quantities of the several nutrients were eaten, production was unaltered.

3. A 6 percent increase or decrease in total dry matter eaten was accompanied by a corresponding 2 percent change in yield; a 10 percent increase or decrease, by a 5 percent change in yield.

The greater the increase or decrease in dry matter consumption the greater the gain or loss in yield, which seemed, however, retarded or augmented somewhat by the protein content of the ration; or, in other words, the milk flow raised and sunk with more or less feed, raising a bit higher and shrinking a bit more as the protein supply became relatively liberal or scant.

4. A 7 percent increase or decrease in digestible dry matter eaten was accompanied by a 3 percent change in yield; a 12 percent increase or decrease, by a 6 percent change in yield; or, in other words, as food varied so did the yield, but to a less degree. When the larger proportions of the digestible dry matter were derived from the grain rations on the one side of the comparison than on the other, there appeared to be a tendency towards a somewhat larger production as a

result of such increase. The outcome in this respect is not clear-cut, being complicated by the generally coincident modifications in the protein content of the rations.

5. As for digestible dry matter, so for digestible carbohydrates and for calories, word for word and, essentially, figure for figure.

6. A 3 percent increase or decrease in digestible protein eaten had no effect on production; a 7 percent increase or decrease was accompanied by a 2 to 3 percent change in yield; and a 22 percent increase or decrease by a 4 to 5 percent change.

When the protein content of the ration was lowered, and other nutrients were eaten in like quantity, yield and cost fell; when it alone among the nutrients was not increased in quantity, there was no loss in yield and cost increased; when it alone was lowered in quantity and all the other nutrients increased, there was no loss in yield or change in cost.

When all the nutrients were lessened proportionately in amount, yield fell, but cost was irregularly affected.

When all nutrients were lessened in amount, protein proportionately most of all, yield fell decidedly and cost likewise lowered.

When the protein content of the ration was raised and other nutrients were eaten in like quantity, yield and cost increased very slightly; when it alone among the nutrients was not decreased in quantity, little or no loss in yield occurred, and slight increase in cost ensued.

When it alone was increased in quantity and all other nutrients decreased, there was no gain in yield and but slight gain in cost.

When all the nutrients were increased proportionately in amount, there was a slight gain in yield and no change in cost.

When all nutrients were increased in amount, protein proportionately most of all, there were large gains in both yield and cost.

When increased from less than to somewhat more than 2 pounds daily the gain in yield approximated 5 percent, and in cost 3 percent and when it shrank from rather more than to rather less than 2 pounds the loss in yield approximated 4 percent, and in cost 5 percent.

When increased from 2 to 2.5 pounds the gain in yield approximated 4 percent, and in cost 2 percent; and when it shrank from 2.5 to 2 pounds the loss in yield reached 6 percent, and in cost 9 percent.

When increased from 2.25 and 2.5 to nearly 3 pounds, the gain in yield approximated 5 percent, and in cost 4 percent; and when it shrank from 3 to 2.25 pounds the loss in yield reached 8 percent, and in cost 3 percent.

7. A change in feeding of from more than to less than 15.5 pounds of digestible nutrients or *vice versa* caused more decided changes in yield than did modifications in feeding on either side of that line, the average figures being 7 percent and 4 percent.

8. The nutritive ratio changes were evidenced in production fluctuations much as were those of digestible protein; when it narrowed, production generally increased, and *vice versa*.

9. The ultimate effect of a given food supply upon the milk flow is doubtless the more or less composite result of several coincidently active factors, including, primarily, changes in the amounts of digestible nutrients taken as a whole; secondarily, changes in the amounts of digestible protein, and, probably, modifications in the proportions of digestible nutrients consumed in concentrates and in roughage.

The writer's study of these data lead him to the conclusion that as a whole they do not support the doctrine which lays extreme stress on the paramountcy of protein; that they indicate that a ration with a nutritive ratio wider than 1:6, perhaps as wide as 1:7, or, indeed, in some cases one slightly wider, may prove economically as effective as the traditional 1:5.4; that a sufficiency of nutrients, affording enough available energy for bodily needs, if carrying a fair amount of digestible protein, not necessarily as much as 2.5 pounds, may prove economically as serviceable as does a richer ration.

What are the views of others?

Jordan says that "the evidence presented concerning one point is fairly consistent and is important, viz.: that changes in the quantity of nutrients have greatly more influence on the milk yield than proportionately large changes in the amount of protein. These data offer strong evidence that if the available energy of the ration is sufficient and is kept at a uniform point, there may be quite a wide range in the nutritive ratio without materially affecting the milk flow."

Haecker maintains that 2 or less pounds of digestible protein daily, derived from home-grown materials, serve equally as well as larger amounts derived in part from purchased byproducts.

Beach states that "rations containing more (digestible) protein than those commonly fed to dairy cows are more economical," particularly "when the original rations carried less than 1.5 pounds of (digestible) protein," but lays "great emphasis . . . . upon the additional value of manure obtainable from the more nitrogenous rations."

FEEDING TRIALS WITH COWS

I. INTRODUCTION

The large size of the station herd admits of much work being done in feeding experimentation, a wide range in choice of animals, much

repetition, and the conduct at one time of a relatively large number of trials. For several years a dual purpose has been held in mind in the plan and execution of these trials, viz.: to add not only to our knowledge as to the relative values of sundry roughages and concentrates but also to test the trustworthiness of the methods used; and it is expected to pursue this line of work for some time in the future.

The experimental feeding of the winter of 1904-05 was directed at the determination of the feeding values of (1) india wheat meal; (2) hominy feed; (3) cottonseed meal; (4) linseed meal.

The records made by 42 cows during the six months' feeding trials are deemed safe to use as a basis for deductions. But little sickness interfered. The results in but a very few cases were impaired because of temporary illness, of early drying off, or because the animal went off feed. The herd has never gone through a winter's trial in better shape or with less disturbance. No serious disturbing factor common to the entire herd was noted.

The feed mixtures were made up by weight of:

No. 1. Wheat bran, 4 parts; cottonseed meal, 1 part; linseed meal, 1 part.
No. 2. Wheat bran, 4 parts; india wheat, 2 parts.
No. 3. Wheat bran, 2 parts; cottonseed meal, 1 part; linseed meal, 1 part; india wheat, 2 parts.
No. 4. Wheat bran, 4 parts; hominy feed, 2 parts.
No. 5. Wheat bran, 2 parts; cottonseed meal, 1 part; linseed meal, 1 part; hominy feed, 2 parts.
No. 6. Wheat bran, 2 parts; cottonseed meal, 1 part.
No. 7. Wheat bran, 2 parts; linseed meal, 1 part.

II. THE FEEDING VALUE OF INDIA WHEAT MEAL

The last report (pages 491-498) detailed a feeding trial of this home-grown concentrate, being the only one which thus far has come to the writer's attention. The outcome was more favorable to the india wheat than was to be expected, judging solely by its analysis. It seemed worth while, therefore, to repeat the observation; especially as such repetitions are in line with the Station's regular policy. The trials paralleled those of last year, comparing it with wheat bran and with cottonseed and linseed meals. It was freely eaten without any observed ill-effects, two and two-thirds pounds daily being fed in combination with bran (as feed No. 2), or with bran, cottonseed and linseed meals (as feed No. 3).

When grain feeds Nos. 1 and 3 were fed, each for 207 days, with hay and silage as roughages, there were:

	No. 1 ration	No. 3 ration	Percentage gain or loss when No. 3 was fed
Pounds of dry matter eaten,	4,531	4,521	0
Pounds of milk made,	3,798	3,815	0
Percent total solids,	14.73	14.74	0
Pounds of fat,	4.34	4.33	0
Pounds of total solids made,	558.5	562.0	+1
Pounds of fat made,	196.5	196.2	0

And to the 100 pounds of dry matter eaten there were:

	No. 1 ration	No. 3 ration	Percentage gain or loss when No. 3 was fed
Pounds of milk,	83.9	84.3	0
Pounds of total solids,	12.3	12.4	+1
Pounds of fat	4.34	4.33	0
Ratio of fat to solids-not-fat; 1:	1.84	1.86	+1

It was said at this point in the discussion of last year's trial that "a closer outcome could not have been looked for on uniform feeding," words which are likewise clearly applicable to the results of this year's test. The footnoted data indicate that such very minor differences, averaging 2 percent, as were developed by the calculations by the other methods tended to favor the bran as against india wheat.

When grain feeds Nos 1 and 2 were fed, each for 138 days, with hay and silage as roughages, there were:

	No. 1 ration	No. 2 ration	Percentage gain or loss when No. 2 was fed
Pounds of dry matter eaten,	2,999	2,984	—1
Pounds of milk made,	2,285	2,166	—5
Percent of total solids,	15.45	15.47	0
Percent of fat,	5.79	5.81	0
Pounds of total solids made,	349.7	333.8	—5
Pounds of fat made,	130.1	123.5	—5

And to the 100 pounds of dry matter eaten there were:

	No. 1 ration	No. 2 ration	Percentage gain or loss when No. 2 was fed
Pounds of milk,	75.7	72.0	—5
Pounds of total solids,	11.6	11.0	—5
Pounds of fat,	4.31	4.12	—4
Ratio of fat to solids-not-fat; 1:	1.67	1.66	—1

When the india wheat meal was substituted for the byproducts of the oil mills, there were made:

1. Five percent less milk, solids, fat and butter.
2. As rich milk.
3. Five percent less products per unit of dry matter eaten.

In last year's trials the cottonseed-linseed ration came out 2 percent ahead; in this year's, 5 percent. It is safe to say that it is somewhat the better of the two.

FINANCIAL CONSIDERATIONS

There is neither market for india wheat nor quotations of it, it being all locally ground for the growers. The Station paid an Orange county miller $32.75 per ton, a prohibitively high price for it, and paid freight in addition. Hence the money side of the comparison possesses little value, though given as a matter of record.

The outcome of the first trial is inevitably in favor of the No. 1 ration. It made a little more milk, a trifle more butter, cost far less and made better manure. The total value of butter, skimmilk

and two-thirds of the fertilizing ingredients for 207 days on each ration were: No. 1, $68.81; No. 3, $68.12; or 69 cents in its favor. It cost $3.09 less and figures a daily net gain per cow of 1.83 cents. In last year's trials the daily net gain per cow was 1.80 cents.

If india wheat can be grown and ground at $20 a ton, it ought to be comparable to wheat bran at the same price. It should be remembered, however, that it is a "heavy" meal, that it does not possess the well-known mechanical properties of bran, and that it is less well adapted than is bran to form the bulk of a grain ration.

The outcome also favors the No. 1 ration in the second trial. Calculations of the value of butter ,skimmilk and two-thirds of the manurial constituents show for the No. 1, $45.14, and for the No. 2 ration, $41.51. The latter costs 74 cents more than did the former; hence the net gain was $4.37 and the daily net gain 3.17 cents. In last year's trials this figure was 2.21 cents.

Cottonseed and linseed meals cost less, made 5 percent more milk and butter and made much better manure. If india wheat can be grown and ground for $15 to $20 per ton there is a better show for its proving a successful competitor of the richer concentrates.

The two years' trials indicate the essential equality in feeding value of wheat bran and india wheat meal, and that the latter is a little poorer than is a mixture of half cottonseed and half linseed meals, when fed in quantities of less than three pounds daily. Quoting last year's report, "This outcome is not one which the analysis of the meal would have led one to anticipate. The cow in other words seems to find more milk-making food in india wheat than does the chemist." To buy it at $32, however, is folly.

III. THE FEEDING VALUE OF HOMINY FEED

Hominy chop (hominy feed) carries the same protein content, less starch, but more fat than does corn meal. Its considerable usage among dairymen and the lack of data experimentally obtained as to its merits as a feed for cows, prompted the Station to undertake to measure its merits last year and to repeat the trials this year.

When grain feeds Nos 1 and 5 were fed, each for 207 days, with hay and silage as roughage, there were:

	No. 1 ration	No. 5 ration	Percentage gain or loss when No. 5 was fed
Pounds of dry matter eaten,	4,506	4,485	0
Pounds of milk made,	2,640	2,816	+7
Percent of total solids,	15.72	15.66	0
Percent of fat,	5.93	5.88	—1
Pounds of total solids made,	413.6	439.6	+6
Pounds of fat made,	155.7	164.8	+6

And to the 100 pounds of dry matter eaten there were:

	No. 1 ration	No. 5 ration	Percentage gain or loss when No. 5 was fed
Pounds of milk,	58.5	62.7	+7
Pounds of total solids,	9.2	9.8	+7
Pounds of fat,	3.46	3.68	+6
Ratio of fat to solids-not-fat; 1:	1.65	1.66	+1

These figures indicate that the hominy feed ration, both directly and per unit of dry matter made as compared with the full bran ration, 6 to 7 percent more milk, total solids, fat and butter. Last year it made 4 percent more milk, and but little more solids or butter. The bran fed last year was far better than was this year's product, undoubtedly a factor in the result. Both years hominy feed outranked bran as a milk producer and more than equalled it as a butter maker.

When grain feeds Nos. 1 and 4 were fed, each 276 days, with hay and silage as roughage, there were:

	No. 1 ration	No. 4 ration	Percentage gain or loss when No. 4 was fed
Pounds of dry matter eaten,	5,906	5,983	+1
Pounds of milk made,	4,396	4,297	—2
Percent of total solids,	15.31	15.33	0
Percent of fat,	5.52	5.53	0
Pounds of total solids,	658.1	647.6	—2
Pounds of fat made,	231.3	229.2	—1

And to the 100 pounds of dry matter eaten there were:

	No. 1 ration	No. 4 ration	Percentage gain or loss when No. 4 was fed
Pounds of milk,	73.5	71.6	—3
Pounds of total solids,	11.0	10.8	—2
Pounds of fat,	3.87	3.81	—2
Ratio of fat to solids-not-fat; 1:	1.77	1.77	0

The No. 1 ration made from 3 to 5 percent more product and from 2 to 4 percent more per unit of dry matter. In last year's trial the cotton-seed-linseed ration made 2 percent less milk but 3 percent more butter, a profound change being observed in the quality of the milk. This odd result was not attained in other trials last year with hominy feed, nor is it in evidence this year.

FINANCIAL CONSIDERATIONS

The No. 1 ration yielded in butter, skimmilk and fertilizing ingredients, $57.23, and the No. 5 ration, $58.95. The former, however, cost 82 cents less, hence the net gain is only 90 cents and the daily net gain but 0.43 cents in favor of the No. 5 ration. It made $2.12 more butter, some 30 cents worth more skimmilk, though carrying over a dollar's worth less plant food. Last year the butter and skimmilk gain barely met the extra cost, thus swaying the pendulum to the

side of the No. 1 ration because of its greater manurial content. Last year the No. 1 ration came out ahead by 0.64 cents daily net gain; this year the No. 5 by 0.43 cents daily net gain. It is the only case observed of materially dissimilar outcome, one year with the other. It is not unlikely that the uneven qualities of the brans fed in the 1904 and 1905 trials is a factor in the result.

When rations Nos. 1 and 4 were fed to the cows for 276 days the butter, skimmilk and fertilizing ingredients (the latter discounted a third) totalled for the No. 1 ration $82.94 and for the No. 4 ration, $78.73, a gain in favor of the former of $4.21. It cost only 84 cents more, however, making the net gain $3.37, or 12.2 cents a day, all of which was due to the increased plant food furnished by the richer byproducts. In other words, the extra 65 cents of butter and skimmilk made on the No. 1 ration did not quite compensate for its added cost. It would appear, then, that hominy meal at $25 did not compare favorably with cottonseed and linseed meals at $28 and $30.

IV. THE FEEDING VALUES OF COTTONSEED AND LINSEED MEALS

Cottonseed and linseed meals have been standard feeds for several decades. Their position in the feeding world is well established and, as "good wine needs no bush," so they ought to need no further demonstration of their merits. Yet they are still too little used, particularly the linseed meal. Then, too, it has so happened that no trials of their relative merits have been thus far carried out at this Station in all the years of its work along feeding lines. Opportunity offering, a somewhat extended test has been made wherein feed mixtures Nos. 1 and 6, Nos. 1 and 7 and Nos. 6 and 7 were competitively fed one against the other. No. 6 differs from No. 1 in containing two and two-third pounds of cottonseed meal in lieu of one and one-third pounds cottonseed and one and one-third pounds linseed. No. 7 differs from No. 1 in containing two and two-thirds pounds of linseed meal in and two-thirds pounds of cottonseed meal in lieu of one and one-third pounds cottonseed meal. And No. 6 differs from No. 7 in carrying two and two-thirds pounds cottonseed meal instead of two and two-thirds pounds linseed meal. Each ration carried five and one-third pounds wheat bran. Thus the substitution of No. 6 or of No. 7 for No. 1 made a minor change, and of No. 6 for No. 7 or *vice versa* a considerable one.

When the cottonseed meal replaced the linseed the results were:

	No. 1 ration	No. 6 ration	Percentage gain or loss when No. 6 was fed
Pounds of dry matter eaten,	4,321	4,359	+1
Pounds of milk made,	3,860	3,998	+4
Percent total solids,	15.26	15.36	+1
Percent fat,	5.72	5.76	+1
Pounds of total solids made,	584.7	608.7	+4
Pounds of fat made,	216.9	226.2	+4

And there were made to the 100 pounds of dry matter eaten:

	No. 1 ration	No. 6 ration	Percentage gain or loss when No. 6 was fed
Pounds of milk,	88.1	90.5	+3
Pounds of total solids,	13.4	13.8	+3
Pounds of fat,	4.97	5.14	+3
Ratio of fat to solids-not-fat; 1:	1.67	1.67	0

The outcome is clear-cut and is identical whichever way the case is figured, viz., a 4 percent gain in production and a 3.5 percent gain per unit of dry matter eaten when the cottonseed meal replaced the linseed meal.

What is the situation when the linseed replaced the cottonseed?

	No. 1 ration	No. 7 ration	Percentage gain or loss when No. 7 was fed
Pounds of dry matter eaten,	4,448	4,411	—1
Pounds of milk made,	3,059	3,073	0
Percent total solids,	15.12	15.04	—1
Percent fat,	5.58	5.50	—1
Pounds of total solids made,	461.6	461.7	0
Pounds of fat made,	169.5	168.3	—1

And there were made to the 100 pounds of dry matter eaten:

	No. 1 ration	No. 7 ration	Percentage gain or loss when No. 7 was fed
Pounds of milk,	68.6	69.5	+1
Pounds of total solids,	10.4	10.5	+1
Pounds of fat,	3.80	3.81	0
Ratio of fat to solids-not-fat; 1:	1.71	1.73	+1

The outcome is less clear here than in the first comparison. The result is practically a tie, the two rations being of equal value.

What is the outcome when Nos. 6 and 7 were pitted against each other?

	No. 6 ration	No. 7 ration	Percentage gain or loss when No. 7 was fed
Pounds of dry matter eaten,	4,422	4,497	+2
Pounds of milk made,	3,670	3,589	—2
Percent total solids,	14.72	14.53	—1
Percent fat,	5.21	5.11	—2
Pounds of total solids made,	530.6	513.4	—3
Pounds of fat made,	183.5	177.4	—3

And to the 100 pounds of dry matter eaten there were made:

	No. 6 ration	No. 7 ration	Percentage gain or loss when No. 7 was fed
Pounds of milk,	82.6	79.7	—4
Pounds of total solids,	12.0	11.4	—5
Pounds of fat,	4.14	3.94	—5
Ratio of fat to solids-not-fat: 1:	1.83	1.84	+1

The outcome is clear again here and all in one direction, namely, a 2 to 3 percent loss in production when linseed meal replaced the cottonseed, and a 4 to 5 percent loss in proportion to dry matter eaten.

How do the three pieces of testimony compare?

1. A 3.5 to 4 percent gain when a small amount of cottonseed meal replaced the linseed meal.

2. No gain when a small amount of linseed meal replaced the cottonseed.

3. A 2 to 5 percent loss when a considerable quantity of linseed meal replaced the cottonseed meal.

These three results seem to concur essentially in according a small though measurable advantage to the cottonseed ration.

FINANCIAL CONSIDERATIONS

Since the cottonseed meal cost less than did the linseed meal, yet made more milk and butter and was richer in manurial ingredients, it follows that it necessarily came out ahead in each trial. The tables in the report furnish ample evidence. Their salient points are:

No. 1 .....$73.09 vs. No. 6 .....$76.19
No. 1 ..... 60.83 vs. No. 7 ..... 59.99
No. 6 ..... 65.73 vs. No. 7 ..... 63.34

DAILY NET GAINS PER COW

No. 6 over No. 1.....1.47 cents
No. 1 over No. 7.....0.43 cents
No. 6 over No. 7.....1.62 cents

In these trials cottonseed meal, even the relatively poor grade fed, won out handily as compared with linseed meal. Yet the writer believes that the latter is an advisable concomitant to use with cottonseed, because of its laxative properties. A high cottonseed ration fed Jersey cows is apt to make, moreover, a hard and crumbly butter, a condition which an addition of linseed meal tends to ameliorate.

VI. SUMMARY

The nature of the problems studied.—Forty-two cows were used in feeding trials which lasted twenty-five weeks and were meant to aid

in the determination, so far as it is possible for single trials to do, of the feeding values of india wheat meal, hominy feed, cottonseed meal, and linseed meal.

India wheat meal, used in medium to small amounts seemed a fair substitute, pound for pound, of wheat bran, and nearly so of a mixture of equal parts of cottonseed and linseed meals, an outcome which its analysis would not have led one to expect and which has been confirmed by the concordant results of two season's trials.

Hominy feed proved superior as a milk-maker to a rather inferior grade of wheat bran, but did not appear to be the equal of cottonseed and linseed meals, nor was it as economical a concentrate to use. This outcome has the coincident testimony of two years' trials to back it.

Cottonseed meal, as compared with linseed meal, seemed to possess a small though measurable advantage as a milk and butter making byproduct; and since it cost less and carried a greater plant food content, it proved economically preferable.

A TRIAL OF THE HEGELUND OR DANISH METHOD OF MILKING

A trial of the so-called Hegelund or Danish method of milking was carried out during the winter and spring with a view of studying its merits. Parallel with it a test of extra-thorough stripping was made. The Hegelund manipulations were devised by the veterinarian of the Ladelund Dairy School, Denmark, and published by the Royal Agricultural Society of Denmark in 1900. Their use is being widely advocated in that country and has undergone review in the hands of Woll, Wing and Foord in the United States.

The manipulations, three in number, have been often described and are meant in general to imitate the movements of the udder produced by the calf. In brief it involves the ordinary practice of milking, followed by a series of hand manipulations; first, of the right quarters, together and upwards, and then of the left quarters similarly; second, of the fore quarters, together and upwards, and then the hind quarters similarly; third, of the fore quarters thrust upwards from below and then of the hind quarters. Each manipulation of each set of quarters is repeated several times and the milk drawn until no more is obtained before the next set is entered upon.

The young man in whose charge the milking of the cows was placed was a cleaner milker than the average. He was charged in no way to alter his usual procedure or to strive to milk more thoroughly. He understood the nature of the trial, knew that it was not meant to be a test of his ability or conscientiousness as a milker, gave it every attention and is thought to have done as he was told.

A consolidation of the data furnishes the following table:

	Milk lbs.	Total solids lbs.	Fat lbs.
Ordinary, 92 days,	1,397	210.1	76.6
do. plus residual, 92 days,	1,450	220.1	80.2
Gain,	53	10.0	3.6
Percent gain,	4	5	5
Ordinary, 138 days,	2,180	322.9	111.9
do. plus extra stripping, 138 days,	2,215	327.9	113.8
Gain,	35	5.0	1.9
Percent gain,	2	2	2

1. Less milk, total solids and fat in the ordinary milking when the residual milking was to follow, than was found when it was not to be carried out; also a slight tendency toward lower quality; *but*

2. More milk, total solids and fat in the ordinary milking and the residual milking together than in the usual product of the comparison period; also a very slight tendency toward better quality.

They show for the four cows which were extra stripped after the ordinary milking was completed:

1. Less milk, total solids and fat in the ordinary milking when the extra stripping was to follow, than was found when the supplementary procedure was not to be carried out; also a lowered quality.

2. Gain in milk, total solids and fat in but a single case when the extra strippings were added.

The cows ate more dry matter while they were residually milked or were extra-stripped than they did during the other periods, the silage then fed being slightly more mature than that used at other times. This increase in food consumption is in the same direction as and closely equivalent to the increase in milk and butter yield. How much of the gain in yield is due to special manipulation and how much to added food consumption is a question.

The manipulations take from three to five minutes to each milking. This would be equivalent to from nine to fifteen hours in the 92 day test, and from fifteen to twenty-three hours in the 138 day one. The immediate returns, 53 pounds of milk or 4 pounds of butter, hardly more than repaid the cost of the extra labor involved in the Hegelund method; while the added work of extra stripping for a return of 2 and a fraction pounds of butter was done at a decided loss. If, as is probably the fact, the persistency of the milking habit and the more perfect development of the udder are encouraged by either procedure, its adoption has considerable justification, particularly with heifers. This

phase of the matter, however, is not included within the scope of the present inquiry. On the other hand, the additional load of dirt, dandruff, hair, dried manure, bacteria, etc., which fall into the milking pail because of the udder manipulation, is a distinct detriment, which, however, the use of some of the covered pails would go far to obviate.

In the Wisconsin trials, which were far more extensive than those now under review, from 8 to 9 percent additional fat was obtained by the Hegelund process and 7 percent by extra stripping. In the Cornell trials, also in some respects of wider scope than the present ones, though conducted for brief periods only, from 7 to 9 percent additional fat was gained by the Hegelund method in two herds and 20 percent in another, where "a young woman," milking seven out of 18 cows in a single herd, left 28 percent of the available fat unmilked, while an "extra harvest hand" left over 40 percent in the udder. They further show almost as much gain from stripping as from Danish manipulation.

Incomplete milking causes large losses, potentially as well as actually. Any scheme which serves to accentuate this loss, to bring it home more forcibly to the average milker, is well worth while. That any special virtue to this end is possessed by a given set of manipulations over thorough stripping, seems to the writer as yet unproven.

A COMPARISON OF UDDER CONFORMATION AND OF MILK PRODUCTION

The conformation of the udder, its approximation in outline to the curve of a semi-circle, its extension therefrom, its balance of quarters, etc., are justly regarded as all important in the judging of a dairy cow. A poorly balanced udder, or one lacking depth, one which is deficient in the fore quarters or is funnel-shaped, or not well carried up behind, is not deemed a perfect milk making mechanism. Is this proposition borne out in fact? Do cows with ill-balanced udders make materially less product than those with glands better proportioned?

The mature animals of the station herd which had made one or more years of record were carefully surveyed and grouped into three lots; those with well-balanced udders, those with fairly well-balanced udders, and those whose udders were deficient, usually in the fore quarters. Every available record of each cow now in the herd was used. The cows were viewed two or three times independently in order to make the more certain that no serious errors in grouping were made.

	Milk	Butter		Milk	Butter		Milk	Butter
Well balanced,	5725	342	Fairly so,	5377	333	Poorly so,	5219	324

The result is not strongly indicative one way or the other, but its tendency is to bear out the score card finding. Four out of five cows with well-balanced udders made more butter than did the average of the eighteen which had but fairly well-balanced udders or the eleven with poorly-balanced udders. They also made more than the average of the herd for twelve years, 324 pounds. Per contra, eight out of the eleven cows with poorly-balanced udders made less butter than did the average of the five whose udders were well built or the eighteen whose glands were fairly well-formed; and their records were all, moreover, below the twelve year herd average of 324 pounds.

MILK FROM FORE AND HIND QUARTERS

A study of the relative quantities and qualities of the milk yield of the fore and hind quarters of the udder was made. Three of the cows had rather poorly-formed udders, the fore quarters being somewhat deficient; the other two carried fairly well-balanced udders. During the first half of this trial the milk from the fore quarters was drawn first, during the second half that from the hind quarters. In all other respects uniformity was observed.

There was no difference in the general outcome whether the fore and hind quarters were milked first. Forty-six percent of the yield of milk, total solids and fat were produced by the fore quarters, and 54 percent by the hind ones. Quality was practically identical in each case. The three cows with rather deficient fore quarters made less milk therein each period.

A trial reported by Beach of three milkings of fifteen cows showed an average of 41 and 59 percents from the front and rear udder.

RECORD OF THE STATION HERD

The average record of 52 cows, members of the herd during the entire year, was:

Days in milk	341
Pounds of milk	5343
Percent of total solids	14.73
Percent of fat	5.25
Pounds of fat	277
Pounds of butter	324
Cost of food	$58.31
Cost of grain	$26.65
Cost of food for 100 pounds of milk	$ 1.13
Cost of food for 1 pound of butter	18½ cts.

Income from sales $96.93
Profit over cost of food.....$38.62
Manurial ingredients in fodders and feeds worth $31.18

The best record for milk, 7843 pounds, Rebecca; butter, 468 pounds, Rebecca; test, 6.62 percent, Lady Perusia; economy of manufacture, milk, 78.3 cents, Rebecca; butter, 13.1 cents, Rebecca.

Three cows, Elsa, Rebecca, and Yttria, made 440 or more pounds of butter.

The poorest records for milk and butter were: Milk, 3555 pounds, Janice; butter, 206 pounds, Epsilon; cost of food per pound of butter, 28⅓ cents, Epsilon.